IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

I hereby certify that this correspondence is being deposited with the U.S. Postal Service with sufficient postage as first class mail in an envelope addressed to: Mail Stop Appeal Brief-Patents, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on March 22, 2004.

Anne Marie Leavy
Signature

Anne Marie Leavy
Printed Name

Applicant	:	Gerald W. Gibson, Jr., et al.
Application No.	:	10/038,371
Filed	:	January 2, 2002
Title	:	SPLIT BARRIER LAYER INCLUDING NITROGEN-CONTAINING PORTION AND OXYGEN-CONTAINING PORTION
Grp./Div.	:	2815
Examiner	:	C.C. Chu
Docket No.	:	MJM/D8143-00331

APPELLANTS' BRIEF

Duane Morris LLP
101 West Broadway, Suite 900
San Diego, CA 92101

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

March 22, 2004

Commissioner:

This is an appeal from the Final Rejection of the claims in the above-referenced application, as made in the Final Office action dated October 22, 2003.

1. REAL PARTY IN INTEREST

The real party in interest is Agere Systems Inc.

2. RELATED APPEALS AND INTERFERENCES

There are no related appeals or interferences which will directly affect or be directly affected by or have a bearing on the Board's decision in the present appeal, that are known to Appellants or Appellants' attorney.

3. STATUS OF CLAIMS

Claims 1-15 are pending in this application. Claims 2, 6, 7 and 11-15 have been objected to and are not the subject of this appeal. Claims 1, 3-5 and 8-10 have been rejected. The rejection of each of claims 1, 3-5 and 8-10, is hereby appealed.

4. STATUS OF AMENDMENTS AFTER FINAL REJECTION

No amendments were filed after the Final Office action of October 22, 2003. A Notice of Appeal was filed on January 21, 2004.

5. SUMMARY OF INVENTION

The present invention provides a method and structure for preventing base groups from become nested in low-k dielectric materials and subsequently rendering photoresist insoluble in semiconductor devices that advantageously use a copper interconnect structure.

Deep Ultra-Violet (DUV) lithography is widely used in the fabrication of advance VLSI (Very Large Scale Integration) semiconductor devices. Chemically amplified DUV photoresists improve the performance of the lithography systems and improve device feature resolution. Low dielectric constant (low-k) dielectrics are favored in today's semiconductor manufacturing industry because of the performance improvement they provide by way of reducing parasitic capacitance, reducing propagation delay and therefore increasing device speed. Copper interconnect features are also favored in today's semiconductor manufacturing industry because they increase device speed and reduce line resistance of the interconnect lines. The present invention enables the combination of each of these advantageous features in semiconductor device manufacturing by providing a composite barrier layer disposed between a copper-containing surface and a low-k dielectric film. The barrier layer comprises a composite film structure including a nitrogen-containing, substantially oxygen-free first film that forms a boundary with a copper containing structure and an oxygen-containing, substantially nitrogen-free second film forming a boundary with the low-k dielectric film.

Base groups such as amines and other N-H based groups are typically produced in association with various films. In particular, the use of copper as an interconnect material requires the use of a barrier layer which typically includes nitrogen and is free of oxygen. The presence of oxygen in a film adjacent to a copper film undesirably causes the formation of copper oxides which degrade adhesion. The formation of such a nitrogen-containing barrier layer film typically produces amine and other N-H based groups. The use of copper typically also includes the use of an organic corrosion inhibitor that typically includes a plasma chemistry including ammonia NH_3. The ammonia-containing chemistry also produces amines or other N-H based groups. The amines and other N-H based groups required in connection with the use of copper interconnect, can diffuse into porous low-k dielectric material and then into the chemically amplified DUV photo resists which they render insoluble.

The barrier layer of the present invention provides a nitrogen-containing barrier layer film that borders the copper film and allows for the use of organic corrosion inhibitors to treat the copper film, but enables the use of the combination of a copper film and low-k dielectric film without the shortcomings associated with the diffusion of amine and other N-H groups diffusing into the low-k dielectric materials.

The present invention therefore enables the combination of the advantageous features of copper interconnect lines, low-k dielectric films and chemically amplified photoresist in DUV lithography systems without degrading the chemically amplified photoresist by interaction with base groups from the porous low-k dielectric film.

6. ISSUES PRESENTED

The issues presented are whether the Examiner properly rejected claims 1, 3-5 and 8-10 in the October 22, 2003 Final Office action.

The first issue presented is whether or not the Examiner properly rejected claims 1, 3-5, 9 and 10 under 35 USC § 102(b), as being allegedly anticipated by U.S. Patent No. 6,265,321 to Chooi et al., hereinafter "Chooi."

The second issue presented is whether or not the Examiner properly rejected claim 8 under 35 USC § 103(a) as being allegedly unpatentable over Chooi in view of U.S. Patent No. 6,140,226 to Grill, hereinafter Grill.

7. GROUPING OF CLAIMS

Claim 1 is an independent claim and claims 3-5, 8 and 9 depend, directly or indirectly from independent claim 1. Each of the rejected claims 1, 3-5, 8 and 9 are presented as standing separately as each of dependent claims 3, 4, 5 and 9 are considered to be separately patentable in combination with claim 1.

Claim 10 is an independent clam that stands separately.

The complete set of rejected claims that are the subject of this appeal, is included in the Appendix (Section 9).

8. ARGUMENT

8A. Final Rejection of Claims 1,3-5, and 8-10.

In the Final Office Action dated October 22, 2003, claims 1, 3-5, 9 and 10 were rejected under 35 USC § 102(e).

In particular, the Examiner rejected claims 1, 3-5, 9 and 10 under 35 USC §102(e) as being anticipated by Chooi.

The Examiner also rejected claim 8 under 35 USC §103(a) as being unpatentable over Chooi in view of Grill.

The Final Office Action of October 22, 2003, also included the Examiner's comments, titled Response to Argument, regarding previously filed arguments included in a response filed by the Appellants, as applicants on May 13, 2003. The May 13, 2003, Response was filed responsive to an Office Action dated December 17, 2002.

Appellants filed a Notice of Appeal on January 21, 2004 in response to the Final Office Action of October 22, 2003.

8B. Claims 1, 3-5, 9 and 10 are not Subject to Rejection Under 35 USC § 102(e) as being Anticipated by Chooi (U.S. Patent No. 6,265,321).

Each of the two independent claims of the present application are directed to a composite barrier layer. The composite barrier layer includes a nitrogen-containing, substantially oxygen-free first film forming a *boundary* with the conductive material and an oxygen-containing substantially nitrogen-free second film forming a *boundary* with a low-k dielectric film.

In particular, claim 1 recites:

1. A semiconductor product comprising a barrier layer disposed between a copper-containing structure and a low-k dielectric film, said barrier layer comprising a composite film structure including a nitrogen-containing, substantially oxygen-free first film forming a boundary with said copper-containing structure and an oxygen-containing, substantially nitrogen-free second film forming a boundary with said low-k dielectric film.

Similarly, independent claim 10 recites:

10. A semiconductor product comprising a barrier layer disposed between a readily-oxidizable conductive material and a low-k dielectric film, said barrier layer comprising a composite film structure including a nitrogen –containing, substantially oxygen-free first film forming a boundary with said conductive material and an oxygen-containing, substantially nitrogen-free second film forming a boundary with said low-k dielectric film.

Because copper (claim 1) is a readily-oxidizable conductive material (claim 10), the scope of the claimed invention clearly includes a copper barrier layer that includes nitrogen. As above, the use of copper interconnect material mandates the use of a nitrogen-containing, substantially oxygen-free film.

In rejecting claims 1, 3-5, 9 and 10, the Examiner recites, on page 2, paragraph 3 of the subject Office Action "Chooi, et al discloses . . . a semiconductor product comprising a barrier layer (24 and 34) . . ". Appellants point out that nowhere in the specification does Chooi refer to either layer 24 or 34 as a barrier layer. In fact, Appellants respectfully submit that Chooi teaches away from films 24 and/or 34 being "barrier layers" because, in column 5 line 63-column 6, line 8, Chooi recites "Interconnection lines 20 . . . . . The interconnect lines may be composed of copper and barrier metal . . . A passivation layer, such as silicon nitride or BLOK (from Applied Materials) 24 is deposited over the copper with barrier metal line. . ." (emphasis added). Because these passages, taken together, indicate that the only barrier material contemplated by Chooi is the barrier metal layer that would be part of the feature illustrated as interconnect line 20, not another feature. Hence, Chooi therefore discloses that layers 24 or 34 are passivation layers and not barrier layers.

In the Final Office Action dated October 22, 2003, the Examiner presumptively rejected claims 1, 3-5, 9 and 10, stating "Chooi et al discloses in Fig. 16, . . . a semiconductor product

comprising a barrier layer (24 and 34) disposed between a copper-containing structure (20 and 12) and a low-k dielectric film (50), said barrier layer (24 and 34) comprising a composite film structure including a nitrogen-containing substantially oxygen-free first film (24) forming a boundary with said copper-containing structure and an oxygen-containing, substantially nitrogen-free second film (34) forming a boundary with said low-k dielectric film".

Actually, Chooi discloses layer 34 as "intermetal dielectric", more particularly IMD1, and discloses layer 24 as "passivation layer 24". Chooi discloses that each of these films may be formed of a variety of materials. However, passivation layer 24 is never disclosed to be a "nitrogen-containing substantially oxygen-free film" and Chooi never teaches or suggests that this layer should be an oxygen-free film. Rather, passivation layer 24 is introduced as "A passivation layer, such as silicon nitride or BLOK (from Applied Materials) 24 is deposited . ." col. 6, lines 6-7. An electronic data base search indicated that "BLOk", the material to which Chooi makes reference, is a proprietary formulation which is a "low k alternative to silicon nitride" (http/www.appliedmaterials.com/products/blok.html). Chooi does not disclose a knowledge of BLOk's formulation to suggest that it is either a "nitrogen-containing" or "substantially oxygen-free film", much less both. Intermetal dielectric layer 34 is never disclosed to be an "oxygen-containing, substantially nitrogen-free film" and, again, Chooi never teaches or suggests that this layer should be a nitrogen-free film. As such, Chooi never teaches or suggests the combination of an oxygen-containing, substantially nitrogen free first film and a nitrogen-containing, substantially oxygen-free second film to produce a composite barrier layer. Applicants respectively submit that the *combination* of these two films used to form a barrier layer directly between a copper/readily-oxidizable film and a low-k dielectric, distinguishes each of claims 1 and 10 from the Chooi reference.

As cited above, the Examiner indicates that film 50 that appears in Fig. 16 of Chooi is a low-k dielectric film he uses to base his claim rejections upon. The Examiner bases his rejection of claims 1 and 10 on Chooi and states, on page 3, lines 1 and 2, that Chooi provides " . . . oxygen-containing, substantially nitrogen-free second film forming a boundary with said low-k dielectric film" (i.e., previously identified as film 50),. Appellants respectively submit that an examination of Fig. 16 of Chooi clearly shows that feature 34 does NOT form a boundary with film 50, as alleged by the Examiner. The claimed invention, in contrast, provides, in each of independent claims 1 and 10 the "oxygen-containing, substantially nitrogen-free second film forming a boundary with said low-k dielectric film."

With respect to film 50, the Examiner has chosen one possible embodiment of film 50, FSG, and introduced another reference (Gillard et al.) to establish that film 50 is a low-k dielectric material. However, in the portions of the specification describing the embodiment covered in Figs. 8-17, film 50 is NOT disclosed to be FSG. Film 50 is simply disclosed to be "intermetal dielectric IMD2 50" in conjunction with Fig. 16, which was relied upon by the Examiner. Appellants point out that nowhere in the specification is it suggested that like reference numbers refer to like features throughout the Drawings. In fact, the specification clearly states that the IMD layers are formed of different materials in the different described embodiments. Referring to the third embodiment covered by Figs 18-26, Chooi states at column 8, lines 6-10 "Two alternatives of this embodiment will be described. In the first alternative, the IMD layers comprise doped or undoped silicon dioxide. In the second alternative, the IMD layers comprise an organic material". The possibility of IMD2 (film 50) being FSG, is limited to the first alternative of the third embodiment – "The first alternative of the third embodiment will be described with reference to FIGS. 19 through 22. In the first alternative, IMD1 and IMD2 comprise undoped silicon dioxide or doped silicon dioxide (e.g. FSG, PSG, BSG, or BPSG)", Chooi at column 8, lines 42-45. This reference to FSG relied upon by the Examiner is limited to the first alternative of the third embodiment shown in Figs. 18-26, and NOT Fig. 16, as suggested by the Examiner. Moreover, it is clear that, film 34 does not form a boundary with film 50 in Figs 18-26, either. In these figures which represent the only embodiment in which film 50 may be FSG, film 48 is interposed between films 34 and 50.

Finally, Appellants point out that each of independent claims 1 and 10 disclose an oxygen-containing, substantially nitrogen free second film forming the boundary . . .. In contrast, the material alleged by the Examiner to be the oxygen-containing, substantially nitrogen free second film (IMD1 34) is shown not to be a film at all in Fig. 16. Rather, Fig. 16 shows IMD1 34 to be a discrete collection of segments separated by air plugs 45. IMD1 34 is clearly not a "*film*" in Fig. 16 of Chooi. Film is defined as "1. a thin skin or membrane", and "3. a thin covering or coating" in the American Heritage Dictionary of the English language, Fourth Edition, 2000, http://www.bartleby.com\61\7\f0120700.html, March 14, 2004. A membrane is known to be a sheet of material and IMD1 34 shown in cross section in Fig. 16, is not a membrane because it includes opening extending therethrough. As such, material 34 is not a film, much less an oxygen-containing, substantially nitrogen free second film, as required in claims 1 and 10.

For reasons stated above, the rejection of independent claims 1 and 10 under 35 USC §102(e) as being anticipated by Chooi, should be reversed. Claims 3-5 and 9 each depend from independent claim 1 and therefore incorporate the distinguishing features of claim 1 and are therefore similarly distinguished from Chooi.

Dependent claims 3, 4, 5 and 9 each recite distinguishing features of the Appellants' invention. Based on the patentability of claim 1, each of claims 3-5, and 9 is also separately patentable because the subject matter of the combination of claim 1 with claims 3, 5, and 9 respectively, is distinguished from the art of record. The rejection of claims 3, 4, 5 and 9 under 35 USC §102(e), should therefore also be reversed.

8C. Claims 8 is not Subject to Rejection Under 35 USC § 103(a).

In the subject Final Office Action, specifically on page 4, paragraph 5, claim 8 was rejected under 35 USC Section 103(a) as being under patentable over Chooi in view of Grill et al. (U.S. Patent No. 6,140,226)

Claim 8 recites: wherein said low-k dielectric film. is formed of "SiOC-H". The Examiner indicates that Grill et al. discloses in column 11, lines 19-23 - a low-k dielectric film being formed of SiOC-H. The cited reference of Grill is not directed to a composite barrier layer described above, and therefore does not make up for the above-stated defiencies of Chooi. Independent claim 1 is distinguished from Chooi for reasons set forth above and since dependent claim 8 depends from claim 1 and because the cited reference of Grill does not make up for the above-stated deficiencies of Chooi, dependent claim 8 is distinguished from the references of record. Furthermore, claim 8 is also separately patentable because the subject matter of the combination of claims 1 and 8 is further distinguished from the art of record. The rejection of claim 8 under 35 USC §103(a), should be reversed.

8D. Conclusion.

In view of the foregoing remarks, Appellants submit that this application is in condition for allowance. Appellants respectfully request that the Board reverse the Examiner's rejection of all rejected pending claims. Appellants again point out that claims 2, 6, 7 and 11-15 were objected to and are not subject to this appeal.

In accordance with 37 CFR Section 1.192(a), this Appeal Brief is being submitted in triplicate. The Commissioner is authorized to charge the fee for filing an Appeal Brief under 37 CFR Section 1.17(c) in the amount of $330 and to charge any additional fees and/or to credit any overpayment of fees which may be required under 37 C.F.R. §1.16 or §1.17, to Deposit Account No 04-1679, referencing Atty. Docket No. D8143-00331.

Respectfully submitted,

DUANE MORRIS LLP

By _____

Mark J. Marcelli
Reg. No. 36,593
619/744-2243

Attachments: Appendix (Section 9)

9. APPENDIX

Claims Under Appeal

1. A semiconductor product comprising a barrier layer disposed between a copper-containing structure and a low-k dielectric film, said barrier layer comprising a composite film structure including a nitrogen-containing, substantially oxygen-free first film forming a boundary with said copper-containing structure and an oxygen-containing, substantially nitrogen-free second film forming a boundary with said low-k dielectric film.

3. The semiconductor product as in claim 1, in which first film comprises silicon nitride and said second film comprises silicon dioxide.

4. The semiconductor product as in claim 1, in which said copper-containing structure comprises a surface including a copper wire formed within an insulating material.

5. The semiconductor product as in claim 1, in which said barrier layer is formed on said copper-containing structure and said low-k dielectric film is formed on said barrier layer.

8. The semiconductor product as in claim 1, wherein said low-k dielectric film is formed of SiOC-H.

9. The semiconductor product as in claim 1, wherein said low-k dielectric film has a dielectric constant less than 3.5.

10. A semiconductor product comprising a barrier layer disposed between a readily-oxidizable conductive material and a low-k dielectric film, said barrier layer comprising a composite film structure including a nitrogen-containing, substantially oxygen-free first film forming a boundary with said conductive material and an oxygen-containing, substantially nitrogen-free second film forming a boundary with said low-k dielectric film.